Seasonal Colonization of Low Profile Artificial Reefs in Mississippi Coastal Waters: Vertebrates

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ABSTRACT

The popularity of low profile reefs as fishing banks prompted the State of Mississippi to develop new artificial reefs and to augment existing oyster shell reefs. The creation of artificial fishing reefs from concrete rubble, crushed limestone, and oyster shells in Mississippi coastal waters provided an opportunity to obtain information on the colonization and utilization of these different substrates by benthic fauna. In this study, vertebrate colonization was compared between two substrate types, crushed limestone gravel and oyster shell. Colonization was determined by placing trays containing the reef material on an existing shell/gravel reef approximately 300 meters from shore in central Mississippi Sound. Every three months the trays were returned to the laboratory and all organisms were removed and identified to the lowest taxonomic level. Fish were measured to the nearest 0.1 mm total length and weighed to the nearest 0.01 g. Fish colonizing the reefs included members of the following families: Gobiidae (*Gobiosoma bosc*), Blenniidae (*Hysoblennius ionthas*), Gobiesocidae (*Gobiesox strumosus*), Ophichthidae (*Myrophis punctatus*), and Batrachoididae (*Opsanus beta*). The structural complexity of the reef appears to control population size structure and density. Differences in species composition and size may be related to the availability and size of "niches" provided by the oyster shell and limestone gravel. Although species composition between the two substrates was similar, significantly larger animals colonized the oyster shell than the crushed limestone gravel. Oyster shells provided fewer, but much larger niches than those found in crushed limestone gravel.

KEY WORDS: Estuarine, fish colonization, low profile artificial reefs

INTRODUCTION

Artificial reefs serve as fish attractants and may increase production of some species by increasing habitat. In an effort to enhance already established recreational fisheries and to increase numbers of and access to less common structure-associated fishes, Mississippi began building new low profile artificial reefs and augmenting existing ones. Although over twenty low profile artificial reefs (oyster shell, concrete rubble, limestone gravel) have been constructed in

Mississippi inshore waters, there are no data on reef community structure or the association of fish populations with these reefs. A study of the faunal assemblages associated with reef colonization in Mississippi Sound was begun in December 1998 as part of a larger program to assess productivity of these reefs in relation to recreational fishing opportunities. The research reported on herein is part of a long-term study addressing seasonal colonization/succession of fauna associated with limestone gravel and oyster shell reefs in estuarine waters of Mississippi Sound. Data represent initial colonization studies conducted in the summer of 1998 and the winter of 1998/99.

MATERIALS AND METHODS

Colonization was studied by placing a series of crates filled with $0.025m^3$ of limestone gravel or oyster shell on a newly created, nearshore limestone/shell reef. The area adjacent the artificial reef is characterized by small patch subtidal oyster beds. Average depth is approximately 1.5 m. Site location is shown in Figure 1. Thirty-two samplers (16 limestone, 16 oyster shell) were deployed in the summer of 1998. The crates were placed on eight plastic pallets, four trays to a pallet (Figure 2). Four pallets held crates filled with limestone and four pallets held crates with oyster shell. All crates and pallets were labeled. A schedule of sampling was established that removed one crate from each pallet (four limestone gravel and four oyster shell) after an initial soak time of 3 months. At six, nine, and twelve month intervals the remaining crates were pulled (four limestone gravel and four oyster shell crates per sampling period). Additionally, a set of crates was replaced (four limestone gravel and four oyster shell) each sampling period in order to obtain a three-month set of samples each season. Original sampling schedule called for removal of a set of three month samples and a set of three and six month
samples during summer and fall of 1998, respectively. Summer samples were collected; however, Hurricane Georges in September 1998 destroyed the pallets and no fall samples were collected. Samplers were re-deployed in December 1998. Data presented in this study are from the three month summer samples (original study) and the three month winter samples that began the new sampling regime.

Crates were removed from the water, immediately placed in seawater soaked oyster sacks and returned to the Gulf Coast Research Laboratory for processing. Contents of each crate were washed over screening and all organisms collected. Samples were frozen prior to analysis. Each sample was sorted to species and the total number and weight recorded. When available, fifty individuals of each species were randomly selected for measurement. Individuals were measured to the nearest 0.1 mm total length (TL) using digital calipers. A Sartorius analytical balance was used to measure weight to the nearest 0.001 g.

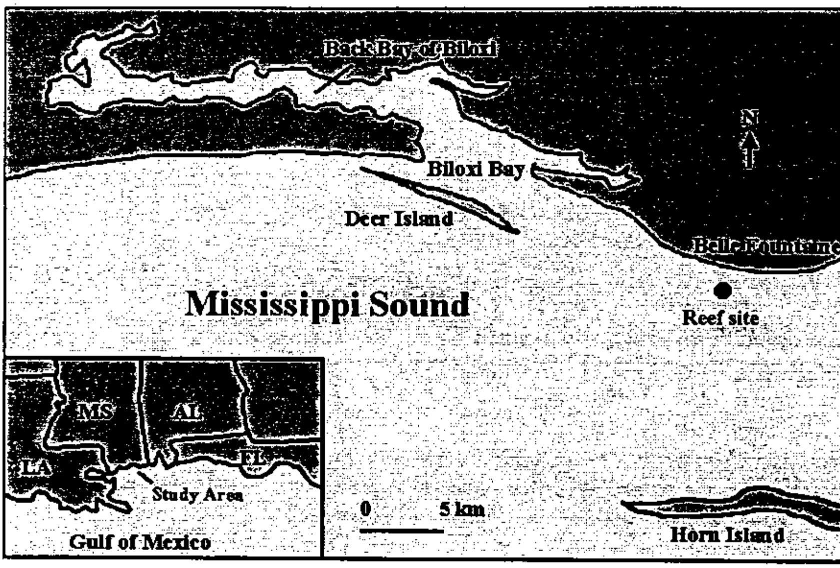

Figure 1. Location of low profile artificial reef.

Student's t-test (α=0.05) was used to compare species abundance and size between substrates within a season and substrates between seasons. Brillouin's diversity index (H) and Spearman's rank correlation (r_S) were calculated to assess species diversity and composition among the samples for each substrate each season. Data were analyzed using the statistical package Quattro Pro Version 8.

RESULTS AND DISCUSSION

Fish associated with limestone gravel and oyster shell substrates for summer and winter samples are listed in Tables 1 and 2. Because the present data are concerned with a limited number of samples that represent a small portion of the uncompleted total study, results are presented with minimal interpretation and discussion.

For some species, observed differences in numbers of individuals and size between summer and winter collections appeared to be related to recruitment, and differences in size between substrates to niche availability. Most of the fish occurring in samples are crevice-dwelling and have been identified as oyster reef associates (White and Wilson 1996).

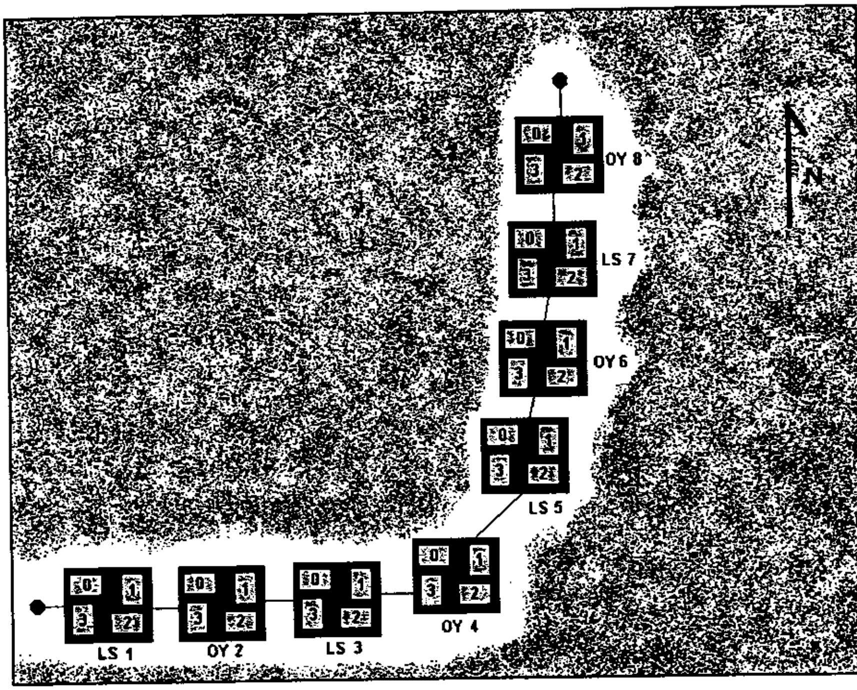

Figure 2. Sampler array

The most abundant fish species found in the samplers was *Gobiosoma bosc.* In summer samples there were significantly higher numbers of *G. bosc* in the limestone than in the oyster shell (Table 1). This was not the case with winter samples due to both low numbers and high variances (Table 2). Numbers of *G. bosc* were significantly higher in the summer samples for both limestone and oyster shell. No size differences were found between substrates in either season (Tables 1 and 2). Gobies were significantly larger in winter limestone samples than summer samples; no seasonal difference in size occurred for oyster shell samples (Table 3). Other gobiid representatives from the winter samples were *G. robustum* and *Bathygobius soporator* with one and two individuals, respectively. *Gobiosoma bosc* is more commonly found on oyster reefs whereas *G. robustum* prefers grassbeds (Hoese and Moore 1998). *Bathygobius soporator* is usually associated with rocky areas and is uncommon in Mississippi Sound (Dawson 1969).

Table 1. Vertebrates associated with gravel and oyster shell substrates during the summer months (N.S.D. = no significant difference, LS = limestone, OY = oyster).

Species	Common Name	Total #		*t*-test for Mean #		Mean Length (mm)		*t*-test for Length	
		LS	OY	*t*	P	LS	OY	*t*	P
Gobiesox strumosus	Skilletfish	25	79	6.57	0.001	28.9 ± 8.5	40.1 ± 8.9	5.57	0.000
Gobiosoma bosc	Naked goby	154	38	4.35	0.022	19.2 ±7.8	21.4 ± 7.4	N.S.D.	
Hypsoblennius ionthas	Freckled blenny	14	38	4.08	0.007	31.8 ± 7.8	50.6 ± 14.2	4.68	0.000
Opsanus beta	Gulf toadfish	8	26	4.70	0.003	17.0 ± 2.8	56.7 ± 47.7	4.22	0.000
Lutjanus griseus	Grey snapper	2	0	N.S.D.		23.5 ± 4.5	-	-	
Myrophis punctatus	Speckled worm eel	11	0	3.67	0.010	89.8 ± 8.5	-	-	
Hypleurochilus geminatus	Crested blenny	0	1	N.S.D.		-	32.4	-	
Hypsoblennius hentz	Feathered blenny	2	0	N.S.D.		16.9 ± 7.1	-	-	
Labrisomus nuchipinnis	Hairy blenny	1	0	N.S.D.		23.1	-	-	
Scartella cristata	Molly Miller	0	1	N.S.D.		-	15.1	-	

Table 2. Vertebrates associated with gravel and oyster shell substrates during the winter months (N.S.D. = no significant difference, LS = limestone, OY = oyster).

Species	Common Name	Total #		*t*-test for Mean #		Average Length (mm)		*t*-test for Len	
		LS	OY	*t*	P	LS	OY	*t*	P
Gobiesox strumosus	Skilletfish	1	23	8.09	0.015	27.3	49.4 ± 11.1	-	
Gobiosoma bosc	Naked goby	16	5	N.S.D.		29.2 ± 13.1	27.0 ± 18.1	N.S.D.	
Hypsoblennius ionthas	Freckled blenny	0	18	12.42	0.000	-	55.0 ± 13.1	-	
Opsanus beta	Gulf toadfish	0	4	N.S.D.		-	47.9 ± 59.8	-	
Bathygobius soporator	Frillfin goby	2	0	N.S.D.		29.5 ± 6.3	-	-	
Chasmodes bosquianus	Striped blenny	0	1	N.S.D.		-	66.7	-	
Gobiosoma robustum	Code goby	1	0	N.S.D.		31.2	-	-	

Table 3. Seasonal comparison of numerical abundance and size for *G. Bosc*, *H. ionthas*, and *G. strumosus*. (N.S.D. = no significant difference, LS = limestone, OY = oyster).

Species	Substrate	Mean Number		*t*-test for Mean		Mean Length (mm)		*t*-test for Mean	
		Summer	Winter	*t*	P	Summer	Winter	*t*	P
Gobiosoma bosc	LS	39 ± 13	4 ± 3	5.02	0.015	19.2 ± 7.8	29.2 ± 13.1	8.16	0.000
	OY	10 ± 1	2 ± 2	7.38	0.000	21.4 ± 7.4	27.0 ± 18.1	N.S.D.	
Hypsoblennius ionthas	LS	4 ± 2	0	4.04	0.027	31.8 ± 7.8	-	-	
	OY	10 ± 6	6 ± 1	N.S.D.		50.6 ± 14.2	55.0 ± 13.1	N.S.D.	
Gobiesox strumosus	LS	6 ± 3	1 ± 1	3.78	0.009	28.9 ± 8.5	27.3	-	
	OY	19 ± 2	8 ± 2	6.81	0.001	40.1 ± 8.9	49.4 ± 11.1	3.69	0.001
Opsanus beta	LS	2 ± 1	0	N.S.D.		17.0 ± 2.8	-	-	
	OY	7 ± 1	1 ± 2	3.49	0.040	56.7 ± 47.7	47.9 ± 59.8	N.S.D.	

Hypsoblennius ionthas was the most common blenny associated with the substrate samplers. Blennies were significantly more abundant and larger on the summer oyster samples than on limestone (Table 1). Higher percentages of small blennies were found in the summer limestone samples whereas larger blennies preferred the summer oyster shell samplers (Figure 3). The blennies from the winter oyster samples were not significantly larger than those in the summer oyster samples (Table 3). No blennies were found on the winter limestone samples (Table 2). Other blenniids collected included: *Hypsoblennius hentz*, *Hypleurochilus geminatus*, *Labrisomus nuchipinnis*, and *Scartella cristata* in the summer, and *Chasmodes bosquianus* in the winter. *Hypsoblennius ionthas* prefers hard bottom substrates, whereas *H. hentz* resides on softer muddy bottoms, and may explain the higher numbers of *H. ionthas* found in the samples compared to other blenniids.

Gobiesox strumosus, skilletfish, was significantly more abundant and larger on oyster shell samplers during both summer and winter (Tables 1 and 2). Summer samples had significantly higher numbers of *G. strumosus* than did winter samples for both substrates (Table 3). In the winter limestone samples, skilletfish were significantly larger than those found in the summer. Skilletfish live on oyster reefs and lay their eggs in empty oyster shells (Runyan 1961). Size distribution of *G. strumosus* from summer samples indicates that smaller individuals utilize the smaller spaces in the limestone samplers while larger animals inhabit the larger spaces provided by the oyster shells (Figure 3). The size distribution from the summer oyster samplers shifted for *G. strumosus* in the winter; no smaller animals were found in any of the winter samples indicating growth and lack of recruitment during this time of year.

Opsanus beta was significantly more numerous and larger in oyster shell than limestone during summer sampling (Table 1). No animals occurred in limestone collectors during the winter (Table 2), and significantly fewer animals were found in winter oyster shell samples than summer samples (Table 3). Large toadfish utilized the larger niches of the oyster samplers and smaller specimens were found in both substrates. The toadfish, or "oyster dog," is a common inhabitant of oyster reefs and rocky jetties (Hoese and Moore 1998).

The speckled worm eel, *Myrophis punctatus*, was only present in summer limestone samplers (Table 1). These eels like to burrow and the small spaces in the limestone samplers offer protection. Small recruiting grey snapper, *Lutjanus griseus*, were only found in summer limestone samplers (Table 1).

The four most dominant species overall were *G. bosc*, *G. strumosus*, *H. ionthas*, and *O. beta*. The Brillouin diversity index (*H*, base 2 scale) was calculated to assess species diversity for each substrate each season. As the species diversity increases the index increases and does not usually exceed 5.0 in biological samples (Krebs 1989). Values were as follows: limestone summer, 1.227; oyster summer, 1.871; limestone winter, 0.791, and oyster winter, 1.597. These indices showed that species diversity was higher in oyster samples both seasons, and higher in summer than winter for both substrates.

Spearman's rank correlation was used to assess the similarity in species composition between the two substrates was. The species composition between the two summer substrates was significantly correlated ($r_S = 0.59$, $p < 0.05$), however, winter samples were not significantly correlated ($r_S = -0.14$, $p > 0.05$). The extremely small number of animals collected in the winter samples may have contributed to the lower correlation.

CONCLUSIONS

For dominant fish species, observed differences in numbers of individuals and size between seasons is related to recruitment. Post-larval and juvenile fish suffer from high mortality rates due to predation. Winter samples had lower numbers but larger animals as the surviving recruits grew. Differences in species composition or size of individuals between substrates were affected by niche availability, the larger the holes the larger the animals that will inhabit them.

Present data represent the first stage of a much larger project. Completion of the seasonal sampling regime will provide a more comprehensive data set from which to evaluate the effect of season and substrate on fish assemblages associated with low profile reefs in estuarine waters. Concurrent studies include a fishery independent finfish sampling program near reef areas and an analysis of the stomach contents of selected fish species in those collections to determine if they are foraging on the reef inhabitants .

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